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General Description of Database Information Version 5.0.1

August 2004

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Assistant Secretary for Environmental Management
Office of Nuclear Material and Spent Fuel

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ABSTRACT

This document consolidates information from Version 5.0.1 of the U.S. Department of Energy (DOE) Office of Spent Fuel Management, Spent Fuel Database (SFD) to provide a general description of DOE spent nuclear fuel. The information provided in this report is further intended to support the *Yucca Mountain Repository Safety Analysis Report*, Chapter 1, "Repository Safety Before Permanent Closure," Section 1.5.1.3, "DOE SNF." This report will allow selected information in the SFD to be used in a readable form traceable to the SFD.

CONTENTS

TABLES

ACRONYMS

B&W	Babcock and Wilcox
BORAX	Boiling Reactor Experiment
DFA	driver fuel assembly
DOE	U.S. Department of Energy
EBWR	experimental boiling water reactor
EOL	end-of-life
FLIP	fuel life improvement program
FRR	foreign research reactor
HEU	highly enriched uranium
HW	heavy water
HWCTR	Heavy Water Components Test Reactor
LEU	low-enriched uranium
LW	light water
MEU	medium-enriched uranium
MOX	mixed oxide
MTHM	metric ton heavy metal
MWd	mega watt day
MTU	metric ton uranium
NSNFP	National Spent Nuclear Fuel Program
PMP	Program Management Procedure
PSO	Program Support Organization
PWR	pressurized water reactor
SFD	Spent Fuel Database
SNAP	System for Nuclear Auxiliary Power
SNF	spent nuclear fuel
SST	stainless steel
TDFA	test driver fuel assembly

TMI-2	Three Mile Island Unit 2
TRIGA	Training, Research, Isotope General Atomics

General Description of Database Information Version 5.0.1

1. PURPOSE

This document consolidates information from Version 5.0.1 of the U.S. Department of Energy (DOE) Office of Spent Fuel Management, Spent Fuel Database (SFD) to provide a general description of DOE spent nuclear fuel (SNF). The information provided in this report is further intended to support the *Yucca Mountain Repository Safety Analysis Report*, Chapter 1, "Repository Safety Before Permanent Closure," Section 1.5.1.3, "DOE SNF." This report will allow selected information in the SFD to be used in a readable form traceable to the SFD.

2. CONTROLS

2.1 Quality Assurance

This document was developed and is controlled in accordance with National Spent Nuclear Fuel Program (NSNFP) procedures. Unless noted otherwise, information must be evaluated for adequacy relative to its specific use if relied on to support design or decisions important to safety or waste isolation.

The NSNFP procedures applied to this activity implement DOE/RW-0333P, *Quality Assurance Requirements and Description*, and are part of the NSNFP Quality Assurance Program. The NSNFP Quality Assurance Program has been assessed and accepted by representatives of the Office of Quality Assurance within the Office of Civilian Radioactive Waste Management for the work scope of the NSNFP. This extends to the work represented in this report.

The principal NSNFP procedures applied to this activity included:

- NSNFP Program Management Procedure (PMP) 6.01, "Review and Approval of Internal NSNFP Documents"
- NSNFP PMP 6.03, "Managing Document Control and Distribution"
- NSNFP Program Support Organization (PSO) 3.04, "Engineering Documentation"
- NSNFP PSO 19.02, "Management of the Spent Fuel Database."

2.2 Inputs

Information from the SFD Version 5.0.1 was used in this report. The resulting queries[1,2] (see attached CD) were developed to provide related information about DOE SNF that has been collected in the SFD Version 5.0.1. The transfer of the information was made according to the requirements of PSO 19.02.

3. GENERAL DESCRIPTION OF DOE SNF

3.1 Diverse DOE Reactor Designs

The following sections show the diverse nature of the reactor designs that produced the existing inventory of DOE fuels.

- **Moderator**—The reactors generating the DOE SNF have used a variety of moderators such as beryllium, graphite, heavy water (HW), light water (LW), Uranium zirc[a] hydride, and organic.
- **Coolant**—The reactors generating the DOE SNF have used a variety of coolants such as air, helium, HW, LW, NaK, nitrogen, none, organic, and sodium.
- **Regulatory Agencies**—The reactors generating the DOE SNF have been regulated by agencies such as Department of Defense, DOE, foreign research reactor (FRR), Nuclear Regulatory Commission, and Nuclear Regulatory Commission Non Power Rx.
- **Mission**—The reactors generating the DOE SNF have been operating for a variety of purposes such as defense power, development power, electric power reactors, experimental power reactor, material production, process development, and test, research and education.

3.2 Diverse Nature of DOE SNF

Most DOE SNF (about 98% of the metric tons of heavy metal) will be shipped and handled in robust canisters that are suitable for codisposal with high-level waste without being opened. Typical commercial power reactor fuels, e.g., Turkey Point Unit 3, Big Rock Point, and Surry Power Reactors 1 and 2 with good cladding conditions, generated about 2% of the metric tons of heavy metal. The following sections show the diverse nature of DOE fuels.

- **Fuel Manufacturers**—DOE SNF has been manufactured from numerous suppliers. Some of these suppliers are no longer producing reactor fuels or have gone out of business. The representative commercial vendors, government suppliers, and foreign suppliers that supported the development of experimental fuels for the DOE laboratories include manufacturers such as: Alco Products, Inc., ANF Framatome (ANP), Argonne National Laboratory-West, Aerojet Gen. Nucleo., Atomics International, B&W and U.S. Nuclear, B&W/Sylvania-Corning, Babcock & Wilcox, Battelle Columbus D., Belgonucleaire, S.A., Classified, Combustion Engineering, Curtis-Wright Corp., D. E. Makepeace, DOE Contractor, Euraton, General Atomics, General Electric CO, Great Lakes Carbon C, Gulf United Nuclear, Idaho National Engineering and Environmental Laboratory, Los Alamos National Laboratory, Martin Marietta, Martin Nuclear, MC Dermott Co., Nuclear Components, Pacific Northwest National Laboratory, Texas Instruments, United Kingdom, Westinghouse, Westinghouse (WAESD), Westinghouse Hanford, and Westinghouse of Canada.
- **Fissile Material**—The fissile material in the DOE SNF includes ^{233}U, ^{235}U, the various nuclides of plutonium, and other transuranics. The ^{235}U enrichment of the DOE SNF ranges from depleted uranium to over 93%. The effective enrichment values pertaining to DOE SNF are adjusted to account for the presence of ^{233}U, plutonium, and other fissile radionuclides. The terms high, medium, and low enrichment referred to in the grouping titles are based on the criteria[3] used during the grouping process. Nominally "High" enrichment were those fuels with enrichments greater than 20% effective end-of-life (EOL) enrichment; "Medium" are those fuels greater than 5% but less than 20% effective EOL enrichments; and "Low" were those fuels with less than 5% effective EOL enrichments. The effective enrichment is defined in the SFD glossary as: The ratio of the fissile mass to the sum of the Total U plus Total Pu expressed as a percentage. Fissile mass (kg) here includes ^{233}U, ^{235}U, ^{239}Pu, and ^{241}Pu. Total U (kg) is the amount of all isotopes of uranium (atomic

a. The term "zirc" is used here to include both zirconium and Zircaloy. The enrichment values pertaining to DOE SNF are end-of-life effective enrichment percents, unless otherwise noted.

number 92) in kilograms, and Total Pu (kg) is the amount of all isotopes of plutonium (atomic number 94) in kilograms. This is further expressed in the following calculation:

Effective enrichment = Total Fissile Mass/(Total U+Total Pu)

- **Compound**—The DOE SNF fuel compound classes include compounds such as Am oxide, Pu oxide, Pu/U alloy, Pu/U carbide, Pu/U nitride, Pu/U oxide, Th/U carbide, Th/U metal, Th/U oxide, U alloy, U carbide, U metal, U oxide, U silicide, and U-Zr hydride. Within these fuel compound classes are fuel compound names, which include: U Metal, U-Zr, U-Metal 2% Zr, U-Mo, UO_2, $U0_2$-BeO_2, U_3O_8, U-AL_X, U_3SI_2, ThC_2-UC2, ThC-UC, ThCO-UCO, Pu/U Carbide, PuO_2-UO_2, PuO_2, ThO_2-UO_2 Ceramic, ThO_2-UO_2, U-ZrH_X-Er, U-ZrH_X, U-10Zr, U-Pu-Zr, Pu/U Alloy, U-Th Metal, U Carbide, Pu/U Nitride, and Am Oxide.

- **Matrix**—The fuel matrixes include materials such as Alum, Alum (1100), B_4C, BEO, Gd_2O_3, graphite, Nichrome, stainless steel (SST), SST (316L), SST 302B, SST 304, SST 304B, SST 347 powder, ZrO_2, and ZrO_2-CaO.

- **Geometry/Cross-Section**—The cross sections of DOE SNF include geometries such as 1/4 circle, 1/8 circle, annulus, circular, cylinder, hexagon, rectangular, rhombus, sphere, square, trapezoid, and triangle.

- **Fuel Unit**—A fuel unit is described as an assembly, scrap plates in a canister, element, plate, scrap in canister, scrap rods in a canister, rods, basket, bundle, canister of rods, scrap, cask, experimental capsule, or canister. The number of fuel units projected to the year 2035 is 247,759.

- **Size**—The size of the DOE SNF is highly variable (see Table 1).

Table 1. The size of DOE spent nuclear fuel.

	Fuel Unit Width (in.)	Fuel Unit Height (in.)	Fuel Unit Length (ft)
Minimum	0.15	0.06	0.29
Maximum	22.27	22.27	14.68

- **Cladding**—Cladding of DOE fuels varies in composition and integrity, from intact to significantly degraded. Some fuels have been declad or have undergone destructive examination. The cladding materials used for DOE SNF include zirconium, aluminum, unknown, SST, none, Nichrome, Incoloy, Hastelloy, mono pyrolytic carbon in graphite, TRISO in graphite, and BISO in graphite. The following criteria are used for categorizing the cladding conditions (see Reference 3):

  Intact fuel is made up of fuel from the good or fair categories.

  Good means no known or suspected through-cladding defects.

  Fair means known or suspected defects are limited to pinhole leaks or hairline cracks.

  Nonintact fuel is composed of fuel from the poor or none category

  Poor means known or suspected defects are greater than pinhole leaks or hairline cracks.

  None means declad or unclad SNF.

- **History**—The burnup of DOE SNF ranges from very slightly irradiated to over 500,000 MWd/MTU. For some DOE SNF, burnup is recorded in terms of ^{235}U Burnup % and Heavy Metal Burnup % consumed rather that MWd/MTU. The burnup for these fuels range from very slightly irradiated to over 80% of the initial ^{235}U to over 70% of the initial heavy metal. The burnup of DOE SNF is provided in Table 2.

Table 2. The burnup ranges of DOE spent nuclear fuel.

	Burnup Min (MWd/MTU)	Burnup Avg (MWd/MTU)	Burnup Max (MWd/MTU)	^{235}U Burnup %	Hvy Metal Burnup %
Minimum	Slightly irradiated	Slightly irradiated	Slightly irradiated	Slightly irradiated	Slightly irradiated
Maximum	262,933	541,344	542,933	87	75.3

Note: Six SFD records[b] indicate a negative ^{235}U burnup %, these values would indicate a production of ^{235}U, but were thorium-based fuels. Two records[c] in the SFD indicate ^{235}U burnup % greater than 99%. One SFD record[d] indicates a negative ^{235}U burnup % and Heavy Metal Burnup %. Another SFD record[e] also indicates a negative Heavy Metal Burnup %. These values were excluded from this range to provide a more realist value.

- **Radionuclide Inventory**—The total DOE SNF radionuclide inventory[4] for the years 2010 and 2030 are provided in Table 3.

Table 3. The radionuclides of DOE SNF.

Radionuclide	2010 Nominal Fuel Inventories (Ci)	2010 Bounding Fuel Inventories (Ci)	2030 Nominal Fuel Inventories (Ci)	2030 Bounding Fuel Inventories (Ci)
H-3	2.45E+05	4.21E+05	1.06E+05	1.92E+05
Be-10	6.12E-01	1.29E+00	6.12E-01	1.29E+00
C-14	1.83E+04	2.79E+04	1.82E+04	2.79E+04
Cl-36	2.98E+02	4.67E+02	2.98E+02	4.67E+02
Cr-51	1.64E-13	2.88E-13	2.36E-14	4.44E-14
MN-54	1.56E+03	2.96E+03	6.03E+02	1.10E+03
Fe-55	7.67E+05	9.71E+05	5.33E+04	1.01E+05
Fe-59	6.83E-08	1.23E-07	1.19E-08	2.28E-08
Ni-59	4.56E+04	7.13E+04	4.56E+04	7.13E+04
Co-60	7.49E+06	9.79E+06	7.98E+05	1.17E+06

b. SHIPPINGPORT LWBR BLKT I [374], SHIPPINGPORT LWBR BLKT II [375], SHIPPINGPORT LWBR BLKT III [376], SHIPPINGPORT LWBR SCRAP [377], SHIPPINGPORT LWBR SCRAP (LINER 15718) [379], and SHIPPINGPORT LWBR SEED [380].

c. VEPCO (T-11) [994] and VEPCO (T-11 RODS) [1049].

d. GCRE (1Z SERIES) [916].

e. AMERICIUM TARGETS [776].

Table 3. (continued).

Radionuclide	2010 Nominal Fuel Inventories (Ci)	2010 Bounding Fuel Inventories (Ci)	2030 Nominal Fuel Inventories (Ci)	2030 Bounding Fuel Inventories (Ci)
Ni-63	5.28E+06	8.20E+06	4.58E+06	7.19E+06
Zn-65	5.97E+03	1.07E+04	7.48E+02	1.35E+03
Se-79	2.91E+02	5.39E+02	2.91E+02	5.39E+02
Kr-85	1.86E+06	3.42E+06	9.54E+05	1.76E+06
Rb-87	1.23E-02	2.19E-02	1.23E-02	2.19E-02
Sr-89	7.33E-03	1.30E-02	3.73E-03	6.70E-03
Sr-90	3.12E+07	5.72E+07	2.27E+07	4.19E+07
Y-90	3.12E+07	5.72E+07	2.27E+07	4.19E+07
Y-91	2.71E-01	4.81E-01	1.39E-01	2.50E-01
Mo-93	1.42E+02	2.21E+02	1.42E+02	2.20E+02
Zr-93	1.68E+03	2.82E+03	1.68E+03	2.82E+03
Nb-93m	1.31E+03	2.18E+03	1.46E+03	2.43E+03
Nb-94	2.37E+02	3.49E+02	2.37E+02	3.49E+02
Nb-95	4.04E+00	7.18E+00	2.06E+00	3.69E+00
Zr-95	1.82E+00	3.23E+00	9.26E-01	1.66E+00
Nb-95m	1.35E-02	2.40E-02	6.87E-03	1.23E-02
Tc-99	8.85E+03	1.63E+04	8.85E+03	1.63E+04
Ru-103	4.07E-06	7.19E-06	1.99E-06	3.58E-06
Rh-103m	3.67E-06	6.48E-06	1.80E-06	3.23E-06
Rh-106	6.26E+05	1.14E+06	2.60E+05	4.67E+05
Ru-106	6.26E+05	1.14E+06	2.60E+05	4.67E+05
Pd-107	4.50E+01	8.55E+01	4.50E+01	8.55E+01
Ag-110	2.74E+00	4.86E+00	1.27E+00	2.28E+00
Ag-110m	2.06E+02	3.65E+02	9.53E+01	1.72E+02
Ag-111	—	—	—	—
Cd-113	—	—	—	—
Cd-113m	5.35E+03	9.93E+03	2.70E+03	5.03E+03
In-114	2.65E-09	4.38E-09	6.94E-10	1.31E-09
In-114m	2.77E-09	4.58E-09	7.26E-10	1.37E-09
Cd-115m	7.78E-08	1.39E-07	4.20E-08	7.50E-08
In-115m	5.47E-12	9.77E-12	2.95E-12	5.27E-12
Sn-119m	5.30E+02	1.01E+03	2.10E+02	4.00E+02
Sn-121m	7.97E+02	1.11E+03	5.82E+02	8.37E+02
Sn-123	2.53E+01	4.54E+01	1.30E+01	2.33E+01

Table 3. (continued).

Radionuclide	2010 Nominal Fuel Inventories (Ci)	2010 Bounding Fuel Inventories (Ci)	2030 Nominal Fuel Inventories (Ci)	2030 Bounding Fuel Inventories (Ci)
Te-123m	7.72E-03	1.21E-02	1.67E-03	3.03E-03
Sb-124	6.47E-05	1.11E-04	3.04E-05	5.47E-05
Sb-125	2.35E+05	4.30E+05	9.38E+04	1.69E+05
Sn-125	—	—	—	—
Te-125m	5.73E+04	1.05E+05	2.29E+04	4.13E+04
Sb-126	3.93E+01	7.21E+01	3.93E+01	7.21E+01
Sn-126	2.81E+02	5.15E+02	2.81E+02	5.15E+02
Sb-126m	2.81E+02	5.15E+02	2.81E+02	5.15E+02
Te-127	1.81E+01	3.25E+01	9.21E+00	1.65E+01
Te-127m	1.84E+01	3.31E+01	9.40E+00	1.69E+01
I-129	1.95E+01	3.63E+01	1.95E+01	3.63E+01
Te-129	3.74E-10	6.61E-10	1.84E-10	3.30E-10
Te-129m	5.75E-10	1.01E-09	2.83E-10	5.07E-10
I-131	—	—	—	—
Xe-131m	—	—	—	—
Xe-133	—	—	—	—
Cs-134	1.85E+06	3.20E+06	6.70E+05	1.21E+06
Cs-135	3.13E+02	5.78E+02	3.13E+02	5.78E+02
Cs-136	—	—	—	—
Ba-136m	—	—	—	—
Cs-137	3.81E+07	7.02E+07	2.77E+07	5.14E+07
Ba-137m	3.60E+07	6.64E+07	2.62E+07	4.86E+07
Ba-140	—	—	—	—
La-140	—	—	—	—
Ce-141	9.27E-09	1.63E-08	4.57E-09	8.21E-09
Ce-142	1.44E-02	2.52E-02	1.44E-02	2.52E-02
Pr-143	—	—	—	—
Ce-144	2.94E+06	5.30E+06	1.44E+06	2.59E+06
Nd-144	6.78E-07	1.21E-06	6.78E-07	1.21E-06
Pr-144	2.94E+06	5.30E+06	1.44E+06	2.59E+06
Pr-144m	3.52E+04	6.36E+04	1.73E+04	3.10E+04
Pm-145	5.39E+02	9.09E+02	2.92E+02	5.00E+02
Sm-145	9.93E+00	1.97E+01	1.40E+00	2.80E+00
Nd-147	—	—	—	—

Table 3. (continued).

Radionuclide	2010 Nominal Fuel Inventories (Ci)	2010 Bounding Fuel Inventories (Ci)	2030 Nominal Fuel Inventories (Ci)	2030 Bounding Fuel Inventories (Ci)
Pm-147	7.51E+06	1.38E+07	3.57E+06	6.43E+06
Sm-147	1.29E-02	2.26E-02	1.30E-02	2.26E-02
Pm-148	1.38E-08	2.49E-08	7.93E-09	1.43E-08
Pm-148m	2.44E-07	4.42E-07	1.41E-07	2.53E-07
Sm-151	5.95E+05	1.08E+06	5.28E+05	9.56E+05
Eu-152	4.67E+03	8.22E+03	2.17E+03	3.84E+03
Gd-153	6.66E+00	1.18E+01	2.56E+00	4.69E+00
Eu-154	8.37E+05	1.51E+06	3.35E+05	6.10E+05
Eu-155	2.94E+05	5.27E+05	9.11E+04	1.65E+05
Eu-156	—	—	—	—
Tb-160	4.96E-04	8.95E-04	1.94E-04	3.54E-04
Tl-206	8.56E-06	1.77E-05	8.56E-06	1.77E-05
Tl-207	4.97E+01	1.01E+02	5.78E+01	1.17E+02
Tl-208	8.93E+03	1.82E+04	8.03E+03	1.63E+04
Pb-210	1.74E-02	2.74E-02	4.04E-02	5.57E-02
Bi-211	4.99E+01	1.01E+02	5.80E+01	1.18E+02
Pb-211	4.99E+01	1.01E+02	5.80E+01	1.18E+02
Bi-212	2.48E+04	5.06E+04	2.23E+04	4.54E+04
Pb-212	2.48E+04	5.06E+04	2.23E+04	4.54E+04
Po-212	1.59E+04	3.24E+04	1.43E+04	2.91E+04
Po-215	4.99E+01	1.01E+02	5.80E+01	1.18E+02
Po-216	2.48E+04	5.06E+04	2.23E+04	4.54E+04
Rn-219	4.99E+01	1.01E+02	5.80E+01	1.18E+02
Rn-220	2.48E+04	5.06E+04	2.23E+04	4.54E+04
Fr-223	6.87E-01	1.40E+00	7.99E-01	1.62E+00
Ra-223	4.99E+01	1.01E+02	5.80E+01	1.18E+02
Ra-224	2.48E+04	5.06E+04	2.23E+04	4.54E+04
Ra-226	3.71E-02	5.39E-02	7.98E-02	1.08E-01
Ac-227	4.98E+01	1.01E+02	5.79E+01	1.18E+02
Th-227	4.92E+01	9.99E+01	5.72E+01	1.16E+02
Ra-228	3.39E+00	6.94E+00	3.43E+00	7.03E+00
Th-228	2.48E+04	5.05E+04	2.23E+04	4.54E+04
Th-229	3.35E+01	6.86E+01	4.76E+01	9.76E+01
Th-230	3.34E+00	4.79E+00	4.89E+00	6.78E+00

Table 3. (continued).

Radionuclide	2010 Nominal Fuel Inventories (Ci)	2010 Bounding Fuel Inventories (Ci)	2030 Nominal Fuel Inventories (Ci)	2030 Bounding Fuel Inventories (Ci)
Pa-231	7.04E+01	1.43E+02	7.05E+01	1.43E+02
Th-231	1.62E+02	2.67E+02	1.62E+02	2.67E+02
Th-232	8.01E+00	8.17E+00	8.01E+00	8.17E+00
U-232	2.42E+04	4.92E+04	2.17E+04	4.42E+04
Pa-233	2.02E+02	3.76E+02	2.10E+02	3.92E+02
U-233	1.82E+04	2.21E+04	1.82E+04	2.21E+04
Pa-234	6.44E-01	1.22E+00	6.44E-01	1.22E+00
Th-234	4.95E+02	9.41E+02	4.95E+02	9.41E+02
U-234	7.25E+03	1.02E+04	7.29E+03	1.03E+04
Pa-234m	4.95E+02	9.41E+02	4.95E+02	9.41E+02
U-235	1.43E+02	2.16E+02	1.43E+02	2.16E+02
Pu-236	2.68E+00	4.85E+00	9.00E-01	1.62E+00
U-236	2.83E+02	4.98E+02	2.83E+02	4.98E+02
Np-237	2.02E+02	3.76E+02	2.11E+02	3.93E+02
Pu-237	9.77E-11	1.58E-10	3.21E-11	5.78E-11
U-237	4.16E+00	7.59E+00	1.96E+00	3.62E+00
Pu-238	9.72E+05	1.79E+06	8.49E+05	1.60E+06
U-238	7.77E+02	7.89E+02	7.77E+02	7.89E+02
Pu-239	4.75E+05	7.71E+05	4.75E+05	7.70E+05
Pu-240	3.65E+05	6.21E+05	3.64E+05	6.20E+05
Am-241	2.11E+06	3.90E+06	2.24E+06	4.13E+06
Pu-241	1.54E+07	3.21E+07	9.38E+06	2.25E+07
Am-242	5.11E+03	9.48E+03	4.73E+03	8.78E+03
Cm-242	4.24E+03	7.88E+03	3.91E+03	7.26E+03
Pu-242	5.05E+02	8.38E+02	5.06E+02	8.38E+02
Am-242m	5.13E+03	9.53E+03	4.75E+03	8.82E+03
Am-243	4.06E+03	7.59E+03	4.05E+03	7.58E+03
Cm-243	1.69E+03	3.23E+03	1.13E+03	2.17E+03
Cm-244	2.32E+05	4.45E+05	1.35E+05	2.58E+05
Pu-244	8.54E-05	1.61E-04	8.54E-05	1.61E-04
Cm-245	7.14E+01	1.39E+02	7.13E+01	1.38E+02
Cm-246	1.10E+01	2.16E+01	1.10E+01	2.15E+01
Cm-247	4.37E-05	8.62E-05	4.37E-05	8.62E-05
Sum	1.91E+08	3.48E+08	1.28E+08	2.41E+08

- **Thermal Power**—The total DOE SNF thermal power (see Reference 4) for the years 2010 and 2030 are provided in Table 4.

Table 4. The thermal power of DOE spent nuclear fuel.

2010 Thermal Power		2030 Thermal Power	
Nominal Heat Output (Watts)	Bounding Heat Output (Watts)	Nominal Heat Output (Watts)	Bounding Heat Output (Watts)
7.18E+05	1.25E+06	4.67E+05	8.54E+05

4. DOE SNF CATEGORIES

All the records are consolidated into a relatively small number of groups (see Reference 3) or categories for the purpose of simplifying the analyses that support licensing of the Yucca Mountain repository. The groups were established based on the following SNF parameters: fuel compound, enrichment, cladding material, and cladding condition. These 34 groups are then used as the basis for further grouping to support analyses such as preclosure safety, criticality, and Total System Performance Assessment. The discussions of each of the 34 groups provide a description of the fuel group and an example of fuel that makes up the group. Where appropriate, a more detailed description of the fuel that represents the majority of the group is given. This discussion is not intended to address each fuel in the group. Table 5 describes ranges of nominal properties for the different types of DOE SNF organized into 34 groups (see Reference 3) or categories of DOE SNF. The discussions described below are for a typical SNF for each group where appropriate:

- **Group 01: U Metal, Zirc Clad, Low-Enriched Uranium**—This group contains uranium metal fuel compounds with zirc cladding SNF. The cladding is in fair to poor condition. This group of fuel comprises approximately 2,103 MTHM. Greater than 99% of the MTHM of fuel in this group is N-Reactor[f] SNF. N-Reactor was used for both material and power production. N-Reactor fuel consists of two concentric tubes about 2.4 in. (6.1 cm) in diameter and typically 2 ft (0.66 m) long. N-Reactor SNF has a nominal enrichment of about 1% and a typical burnup of about 2,400 MWd/MTU. The cladding condition of the N-Reactor is poor.

- **Group 02: U Metal, Nonzirc Clad, Low-Enriched Uranium**—This group contains uranium metal fuel compounds with no known zirc cladding. The nonzirc cladding is in good, fair, and poor condition. This group of fuel comprises approximately 8 MTHM. The Single Pass Reactor[f] (SPR) generated the largest single source of SNF in this group (over 40% of the MTHM). The SPR was used for material production. The SPR SNF consists of circular tubes roughly 1.5 in. (3.7 cm) in diameter and 0.66 ft (0.2 m) long. The SPR SNF has a nominal enrichment of about 1% and an average burnup of about 3,000 MWd/MTU. The cladding condition of the SPR SNF is generally poor.

f. Record ID 991.

Table 5. Ranges of nominal properties for DOE spent nuclear fuel.

Fuel Group	EOL Effective Enrichment (%)	Cladding Composition	Cladding Condition	Fuel Compound Names	Fuel Matrix	Configuration	Length (ft)	Width/ Height/ Diameter (in.)
01. U metal, zirc clad, LEU	1.7–0.5	Zirconium	Fair Poor	U metal	None	Plates Tubes	2.1–9.9	1.0–4.3
02. U metal, nonzirc clad, LEU	3.4–0.2	SST Aluminum	Poor Good Fair	U metal	None	Cans of scrap Tubes None	0.6–0.9	1.4–1.9
03. U-zirc	92.9–0.5	Zirconium	Fair Good	U metal 2% Zr U-Zr	None	Tube Cylinders Plates	2.0–12.5	2.0–7.4
04. U-Mo	25.8–2.4	Zirconium Aluminum None	Good Poor Fair None	U-Mo	None	Rod Tube Plates in can	1.0–3.8	0.1–2.1
05. U oxide, zirc clad, intact, HEU	92.5–23.1	Zirconium	Fair Good	UO_2	ZrO_2-CaO Graphite ZrO_2	Rod Assembly Plates	3.1–9.0	0.3–7.4
06. U oxide, zirc clad, intact, MEU	6.9–5	Zirconium	Fair Good	UO_2	None	Plates Rod Cans of rods Element	2.9–5.2	0.3–3.8
07. U oxide, zirc clad, intact, LEU	4.9%–0.6	Zirconium	Good Fair	UO_2	None	Tubes Rod Plates Assembly	0.8–14.7	0.4–8.5
08. U oxide, SST/hastelloy clad, intact, HEU	93.2–91.0	SST Hastelloy	Good Fair	U oxide UO_2	SST SST (316L) SST 304B SST 304 None	Tubes Cans of scrap Rod Plates Rod assembly	2.1–6.6	0.9–3.7
09. U oxide, SST clad, intact, MEU	20.0–5.5	SST	Good Fair	UO_2-BeO_2 UO_2	ZrO_2-CaO None	Rod Element	2.4–4.0	0.3–1.5
10. U oxide, SST clad, intact, LEU	1.9–0.2	SST	Good Fair	UO_2	None	Tube Rod	1.5–12.0	0.4–8.5

Table 5. (continued).

Fuel Group	EOL Effective Enrichment (%)	Cladding Composition	Cladding Condition	Fuel Compound Names	Fuel Matrix	Configuration	Length (ft)	Width/ Height/ Diameter (in.)
11. U oxide, nonalum clad, nonintact or declad, HEU	93.3–21.0	Nichrome Hastelloy SST Zirconium None	Poor None	UO_2	BEO SST Nichrome None	Cans of scrap	0.2–2.8	2.8–5.6
12. U oxide, nonalum clad, nonintact or declad, MEU	18.6–5.2	None Zirconium SST	Poor	UO_2	Gd_2O_3 None SST	Experiment capsule Scrap Cans of scrap	3.4–9.9	0.4–9.1
13. U oxide, nonalum clad, nonintact or declad, LEU	3.2–1.1	Zirconium SST	Poor	UO_2	None	Cans of scrap Scrap Rod	12.4–13.5	0.5–14.0
14. U oxide, alum clad, HEU	89.9–58.1	Aluminum	Good Fair	U_3O_8	Alum	Plates	2.0–3.6	2.8–17.2
15. U oxide, alum clad, MEU and LEU	20.0–8.9	Aluminum	Good Fair	U_3O_8	Alum	Plates Assembly	2.2–3.3	3.0–4.8
16. U-ALx, HEU	93.3[a]–21.9	Aluminum	Good Fair	U-ALX	Alum	Rods Tubes Plates Pin cluster Assemblies Elements	0.4–10.1	1.3–16.3
17. U-ALx, MEU	20.0–9.0	Aluminum	Good Fair	U-ALX	Alum	Assembly Element Plates	2.0–3.4	2.1–4.1
18. U_3Si_2	22.0–5.2	Aluminum	Good Fair Poor	U_3SI_2	Alum	Tubes Multi-pin cluster Assembly Cans of Scrap	2.0–3.4	2.6–4.1
19. Th/U carbide, TRISO or BISO coated particles in graphite	84.4–71.4	BISC TRISO	Good	ThC_2-UC_2 ThC-UC	Graphite	Tubes Cans of scrap	2.6–10.5	3.5–14.2

Table 5. (continued).

Fuel Group	EOL Effective Enrichment (%)	Cladding Composition	Cladding Condition	Fuel Compound Names	Fuel Matrix	Configuration	Length (ft)	Width/ Height/ Diameter (in.)
20. Th/U carbide, mono-pyrolytic carbon coated particles in graphite	93.2–80.6	Mono-pyrolytic carbon	Poor	ThCO-UCO ThC_2-UC_2	Graphite	Element Carbon coated part Cans of Scrap	~12.0	~3.5
21. Pu/U carbide, nongraphite clad, not sodium bonded	67.3–1	SST	Good Fair Poor	Pu/U carbide	None	Element Cans of scrap Rod	7.7–12.0	0.2–5.2
22. MOX, zirc clad	21.3–1.3	Zirconium	Poor Good Fair	PuO_2-UO_2	None	Rod Cans of Scrap Plates Element	3.3–7.1	0.3–6.6
23. MOX, SST clad	87.4[b]–2.1	SST	Poor Good Fair	PuO_2-UO_2 PuO_2	None	Rod Plates Element Cans of Scrap Scrap	1.1–12.0	0.2–9.1
24. MOX, non-SST/nonzirc clad	54.3–5	Unknown	N/A Poor	PuO_2-UO_2	None Unknown	Scrap Cans of scrap	Unknown	Unknown
25. Th/U oxide, zirc clad	98.4–10.1	Zirconium	Good Poor N/A	ThO_2-UO_2 ceramic	None	Rod Assembly Cans of scrap	~11.8	9.0–22.3
26. Th/U oxide, SST clad	97.8–7.6	SST	Fair Good Poor	ThO_2-UO_2	None	Assembly Cans of scrap Rod	5.2–11.7	0.4–11.9
27. U-zirc hydride, SST/incoloy clad, HEU	93.2–42.5	SST Incoloy	Good Fair	U-ZrHX-Er	None	Rod Element	2.4–3.8	0.5–3.2
28. U-zirc hydride, SST/incoloy clad, MEU	20.0–11.9	SST Incoloy	Good Poor	U-ZrHX U-ZrHX-Er	None	Element Canister of scrap	2.4–3.8	~1.5
29. U-zirc hydride, alum clad, MEU	20.0–16.8	Aluminum	Good	U-ZrHX	None	Element	~2.4	~1.5
30. U-zirc hydride, declad	~89.7	None	N/A	U-ZrHX	None	Declad rod	~1.2	~1.2

Table 5. (continued).

Fuel Group	EOL Effective Enrichment (%)	Cladding Composition	Cladding Condition	Fuel Compound Names	Fuel Matrix	Configuration	Length (ft)	Width/ Height/ Diameter (in.)
31. Metallic sodium bonded	93.2-<0.1	SST None Unknown	Poor Good N/A Fair	PuO_2-UO_2 U-10Zr U-Mo U-10Zr U metal U-Pu-Zr UO_2 U metal Pu/U alloy U-5 fissium Pu/U carbide	None	Fuel in sodium Rod Assembly Cans of Scrap Scrap	1.8–12.0	0.2–9.1
32. Naval	—	—	—	—	—	—	—	—
33. Canyon stabilization	—	—	—	—	—	—	—	—
34. Misc (not previously listed)	90.0–14.6	None Zirconium Unknown Aluminum SST	Fair Poor N/A Good	ThO_2-UO_2 U-Th metal U metal Am oxide Pu/U nitride	None Alum (1100) Unknown	Cans of scrap Tube Rod	0.3–9.9	0.5–2.6

a. Excludes record BER-II [HMI] (END BOXES) (GERMANY) [892] at 100% enrichment to provide a more realist value.

b. Excludes record EPRI [67] at 100% enrichment to provide a more realist value.

- **Group 03: U-Zirc**—This group contains uranium alloy fuel compounds, uranium zirc and U-Metal 2% zirc, with zirc cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 0.66 MTHM. Greater than 99% of the MTHM of fuel in this group is a variety of fuel from the Heavy Water Components Test Reactor (HWCTR).[g] HWCTR SPR[h] (semi-production run) SNF is the dominant SNF in this group (67% of the MTHM). The HWCTR SPR SNF consists of circular tubes about 2.1 in. in diameter and 11 ft long. The HWCTR SPR SNF is about 0.6% enriched. The condition of the HWCTR SPR SNF cladding is fair.

- **Group 04: U-Mo**—This group contains uranium alloy fuel compounds and uranium-molly SNF with various types of cladding. This group of fuel comprises approximately 3.9 MTHM. More than 99% of the MTHM of the SNF in this group was generated in the Enrico Fermi Atomic Power Plant Cores 1 and 2 (Fermi),[i] and the majority (over 90% of the MTHM) of the SNF in this group consists of Fermi standard fuel subassemblies.[j] Fermi driver fuel consists of rods roughly 0.16 in. in diameter and 2.7 ft in length. The Fermi standard fuel subassembly SNF has an enrichment of about 26% and an average burnup of about 1,600 MWd/MTU. The condition of the Fermi standard fuel subassembly SNF cladding is considered good.

- **Group 05: U Oxide, Zirc Clad, Intact, Highly Enriched Uranium**—This group contains uranium oxide fuel compounds with zirc cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 1 MTHM. Greater than 90% of the MTHM of the SNF in this group consists of Shippingport Pressurized Water Reactor (PWR) Core 2 S-1 and S-2,[k] which is uranium oxide compound dispersed in a zirconium-oxide (Seed 1) or zirconium-oxide calcium-oxide (Seed 2) matrix. Shippingport PWR was a light water moderated and cooled electricity power reactor. Shippingport PWR fuel assemblies consist of 19 flat plates, which are 7.4 in. square and about 8.7 ft long. The Shippingport PWR SNF has an enrichment of about 69 to 81% and a burnup of roughly 38% of the initial fissile mass. The condition of the Shippingport PWR fuel cladding is good.

- **Group 06: U Oxide, Zirc Clad, Intact, Medium-Enriched Uranium**—This group contains uranium oxide fuel compounds with zirc cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 1.9 MTHM. Greater than 80% of the MTHM in this group consists of Experimental Boiling Water Reactor (EBWR).[l] The EBWR was a DOE light water cooled and moderated experimental power reactor. EBWR SNF consists of plate-type assemblies, roughly 3.75 in. square and 5.2 ft long. EBWR SNF has an enrichment of 6% and a maximum burnup of 1,600 MWd/MTU. The cladding condition of the EBWR SNF is considered fair.

- **Group 07: U Oxide, Zirc Clad, Intact, Low-Enriched Uranium**—This group contains uranium oxide fuel compounds with zirconium cladding. The cladding is in good to fair condition. This

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g. Record IDs 117, 783, 880, and 977.

h. Record ID 783.

i. Record IDs 453 and 456.

j. Record ID 456.

k. Record IDs 195 and 196.

l. Record ID 65.

group of fuel comprises approximately 89.6 MTHM. The majority (75% of the MTHM) of the SNF in this group was generated by typical commercial power reactors such as the Robert E. Ginna, Big Rock Point, Surry, and Turkey Point reactors. The commercial power reactor SNF configuration includes intact rod arrays. The commercial power reactor SNF in this group has enrichments ranging from 0.6 to 2.9%. The average burnup of the commercial power reactor SNF in this group ranges from about 1,600 MWd/MTU for some Big Rock Point SNF to about 43,000 MWd/MTU for the Calvert Cliffs 1 SNF. The cladding condition of the commercial power reactor SNF in this group is considered good.

- **Group 08: U Oxide, SST/Hastelloy Clad, Intact, Highly Enriched Uranium**—This group contains uranium oxide fuel compounds, UO_2 and UO2-BeO_2, with stainless steel or hastelloy cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 0.19 MTHM. Roughly 40% of the MTHM of the SNF in this group was generated by superheaters for the Pathfinder Atomic Power Plant Reactor and fuel from the Boiling Reactor Experiment (BORAX V).[m] The Pathfinder SNF[n] consists of rods 0.9 in. in diameter and 6.5 ft long. The BORAX V SNF consists of flat plate assemblies 3.7 in. wide and 2.1 ft long. The SNF in this group has an enrichment of roughly 93%. The Pathfinder and BORAX V SNF in this group has a burnup of less than 6% of the initial fissile mass, and the cladding condition is considered good or fair.

- **Group 09: U Oxide, SST Clad, Intact, Medium-Enriched Uranium**—This group contains uranium oxide fuel compounds, UO_2 and UO2-BeO_2, with stainless steel cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 0.69 MTHM. Greater than 80% of the MTHM of the SNF in this group was driver fuel for the Power Burst Facility (PBF) SNF,[o] which was a test reactor, designed to investigate fuel performance during accident conditions. The PBF SNF consists of rods measuring 0.75 in. in diameter and 4 ft in length. The PBF SNF has an enrichment of about 18% and an average burnup of about 500 MWd/MTU. The Power Burst Facility cladding condition is considered good.

- **Group 10: U Oxide, SST Clad, Intact, Low-Enriched Uranium**—This group contains uranium oxide fuel compounds with stainless steel cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 0.9 MTHM. This group contains a small amount of material, over 40% of which by MTHM was generated by Connecticut Yankee reactors. The Connecticut Yankee SNF[p] is typical commercial power reactor SNF except that it has stainless steel cladding. The Connecticut Yankee SNF has an enrichment of 1.9%. The Connecticut Yankee SNF has a burnup of about 32,000 MWd/MTU. The cladding condition of the Connecticut Yankee SNF is good.

- **Group 11: U Oxide, Nonalum Clad, Nonintact or Declad, Highly Enriched Uranium**—This group contains uranium oxide fuel compounds, UO_2 UO2-BeO_2 and U_3O_8, with no known aluminum cladding. The nonaluminum cladding is in poor condition with not intact integrity. This group of fuel comprises approximately 0.82 MTHM. About 60% of the MTHM of the SNF in this

m. Record ID 22.

n. Record IDs 166 and 814.

o. Record ID 167.

p. Record ID 34.

group is generated from FRRs in Canada. The Canadian FRR targets[q] have an enrichment of about 50%. There is no cladding on the Canadian FRR targets.

- **Group 12: U Oxide, Nonalum Clad, Nonintact or Declad, Medium-Enriched Uranium**—This group contains uranium oxide fuel compounds with no known aluminum cladding. The nonaluminum cladding is in poor condition. This group of fuel comprises approximately 0.47 MTHM. A vast majority of the fuel in this group (greater than 75% of the MTHM) is from the Loss of Fluid Test[r] and Power Burst Facility[s] Reactors. The SNF in this group has enrichments ranging from 5 to nearly 19%. The cladding condition of the SNF in this group is either poor or the cladding has been removed.

- **Group 13: U Oxide, Nonalum Clad, Nonintact or Declad, Low-Enriched Uranium**—This group contains uranium oxide fuel compounds with no known aluminum cladding. The nonaluminum cladding is in poor condition. This group of fuel comprises approximately 82.5 MTHM. Ninety-nine percent of the MTHM of the SNF in this group is core debris from the Three Mile Island Unit 2 reactor accident. The TMI-2[t] fuel has an enrichment of about 2.4% and a burnup of about 3,200 MWd/MTU. The cladding condition of the Three Mile Island Unit 2 SNF is poor.

- **Group 14: U Oxide, Alum Clad, Highly Enriched Uranium**—This group contains uranium oxide fuel compounds, U_3O_8, with aluminum cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 4.6 MTHM. Greater than 80% of the MTHM of the SNF in this group is from the High Flux Isotope Reactor (HFIR).[u] HFIR is a DOE test reactor. The HFIR SNF consists of two concentric assemblies consisting of curved involute plates that are separated for disposal. The outer assemblies are about 17 in. in diameter and 2.6 ft long and the inner assemblies are about 12 in. in diameter and 2.5 ft. long. The HFIR SNF has an enrichment of about 87%. The HFIR SNF has an average burnup of about 230,000 MWd/MTU. The cladding condition of HFIR SNF is good.

  Group 15: U Oxide, Alum Clad, Medium-Enriched Uranium and Low-Enriched Uranium—This group contains uranium oxide fuel compounds, U_3O_8, with aluminum cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 0.29 MTHM. Nearly all the SNF in this group was generated from a number of FRRs. The largest single source (56% of the MTHM) is the G. A. Siwabessy RSG-GAS-30[v] reactor in Indonesia. This Indonesia FRR SNF consists of square assembly of plate-type fuel with a typical width of 3 in. and a length of about 2.9 ft. This Indonesian FRR SNF has an enrichment of about 10% and a burnup of about 50% of the initial fissile mass. The cladding condition of most of this Indonesian FRR SNF in this group is good.

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q. Record ID 671.

r Record IDs 923 and 924.

s Record ID 1062.

t. Record IDs 228, 229, and 914.

u. Record IDs 103, 1083, and 1084.

v. Record ID 502.

- **Group 16: U-Al_x, Highly Enriched Uranium**—This group contains uranium alloy fuel compounds, Al_x, with aluminum cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 7.5 MTHM. The SNF in this group is generated from domestic and foreign test, research, and education reactors. The Advanced Test Reactor (ATR)[w] is the largest single source of SNF in this group, accounting for 67% of the MTHM. The ATR SNF consists of curved plate assemblies about 4.2 in. wide, 2.6 in. high, and 5.5 ft long before being cropped to about 4.1 ft for storage. The ATR SNF has a typical enrichment of about 80% with an average burnup of about 250,000 MWd/MTU. The cladding condition of ATR SNF is good.

- **Group 17: U-Al_x, Medium-Enriched Uranium**—This group contains uranium alloy fuel compounds, Al_x, with aluminum cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 2.6 MTHM. The SNF in this group is generated from numerous domestic and foreign test, research, and education reactors. The largest single source of SNF in this group (30% of the MTHM) is the R-2 reactor[x] in Sweden. The R-2 SNF is a square assembly of plate-type fuel about 3 in. wide and about 2.9 ft long. The R-2 SNF has an enrichment of about 9% and a burnup of 60% of the initial fissile mass. The cladding condition of the SNF in this group is generally good.

- **Group 18: U_3Si_2**—This group contains uranium-silicide fuel compounds, U_3SI_2, with aluminum cladding. The cladding is in good, fair to poor condition. This group of fuel comprises approximately 7.2 MTHM. The SNF in this group is generated from numerous domestic and foreign test, research, and education reactors. About 45% of the MTHM in this group consists of FRR multi-pin clusters generated by the National Research Universal (NRU) reactor in Canada[y]. The NRU reactor is heavy water moderated and cooled. The NRU SNF has a typical enrichment of about 5.6% and a burnup of about 76% of the initial fissile mass. The cladding condition of the NRU SNF is good.

- **Group 19: Th/U Carbide, TRISO or BISO-Coated Particles in Graphite**—This group contains thorium/uranium carbide fuel compounds, ThC_2-UC_2 and ThC-UC , with TRISO or BISO-coated particles. The coating is in good condition. This group of fuel comprises approximately 24.7 MTHM. About 95% of the MTHM of the SNF in this group was generated from the Fort St. Vrain Reactor.[z] The Fort St. Vrain SNF consists of hexagonal graphite blocks about 14 in. wide by 2.6 ft long containing TRISO-coated (i.e., inner pyrocarbon, silicon carbide, and outer pyrocarbon coatings) particles. The Fort St. Vrain SNF has an enrichment of about 80% and burnups of about 45% of the initial fissile mass. The cladding condition of the Fort St. Vrain SNF is good.

- **Group 20: Th/U Carbide, Mono-Pyrolytic Carbon-Coated Particles in Graphite**—This group contains thorium/uranium carbide fuel compounds, ThC_2-UC_2 and ThC-UC, with mono-pyrolytic carbon-coated particles. The coating is in poor condition. This group of fuel comprises approximately 1.6 MTHM. Nearly all (greater than 99%) of the SNF in this group is Peach Bottom Unit 1 Core 1 SNF.[aa] The Peach Bottom Unit 1 reactor was a helium cooled, graphite moderated,

w. Record IDs 15 and 16.

x. Record ID 523.

y. Record ID 660.

z. Record IDs 85 and 86.

aa. Record IDs 169, 170, and 1085.

electric power reactor. The Peach Bottom Unit 1 SNF is about 3.5 in. wide and 12 ft long. The Peach Bottom Unit 1 core 1 SNF has a typical enrichment of about 86% and a burnup of about 30% of the initial fissile mass. The cladding condition of the Peach Bottom Unit I core I SNF is considered poor.

- **Group 21: Pu/U Carbide, Nongraphite Clad, Not Sodium Bonded**—This group contains plutonium/uranium carbide fuel compounds with stainless steel cladding. The cladding is in good, fair, to poor condition. This group of fuel comprises approximately 0.08 MTHM. The FFTF reactor was a sodium-cooled DOE test and research reactor. About 56% of the MTHM in the group is the FFTF test fuel assembly TFA-FC-1.[bb] The FFTF TFA-FC-1 assembly cross-section is a hexagonal about 4.6 in. across the flats, 5.2 in. across the points, and the SNF is 12 ft long. The FFTF TFA-FC-1 SNF is about 21% enriched and has a burnup of about 60,000 MWd/MTU. The FFTF TFA-FC-1 cladding condition is good.

- **Group 22: MOX, Zirc Clad**—This group contains plutonium/uranium oxide fuel compounds with zirconium cladding. The cladding is in good, fair, to poor condition. This group of fuel comprises approximately 1.6 MTHM. About 60% of the MTHM in this group is EBWR SNF,[cc] which experimented with the recycling of plutonium. The EBWR SNF has an enrichment of 1.6% and a burnup of 3% of the initial fissile mass. The EBWR cladding condition is fair.

- **Group 23: MOX, SST Clad**—This group contains plutonium/uranium and plutonium oxide fuel compounds with stainless steel cladding. The cladding is in good, fair, to poor condition. This group of fuel comprises approximately 10.7 MTHM. About 80% of the MTHM of this group is FFTF driver fuel assemblies and test driver fuel assemblies (DFA/TDFAs). The FFTF-DFA/TDFA[dd] assembly cross-section is a hexagonal about 4.6 in. across the flats, 5.2 in. across the points, and the SNF is 12 ft long. The FFTF DFA/TDFA SNF has enrichments of about 24% and an average burnup of about 70,000 MWd/MTU. The condition of most of the FFTF DFA/TDFA SNF cladding is fair.

  Group 24: MOX, Non-SST/Non-Zirc Clad—This group contains plutonium/uranium oxide fuel compounds with no known stainless steel or zirc cladding. The nonzirc and nonstainless steel cladding is in poor to nonintact condition. This group of fuel comprises approximately 0.11 MTHM. The majority of the SNF in this group (97% of the MTHM) is MOX scrap[ee] with an enrichment of about 15%. The cladding condition of the SNF in this group is either poor or nonexistent.

- **Group 25: Th/U Oxide, Zirc Clad**—This group contains thorium/uranium oxide fuel compounds, ThO_2-UO_2 Ceramic and ThO_2-UO_2, with zirconium cladding. The cladding is in good to poor condition. This group of fuel comprises approximately 42.6 MTHM. All the SNF in this group was generated by the Shippingport Atomic Power Station with Shippingport LWBR assemblies.[ff]

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bb. Record ID 325.

cc. Record ID 63.

dd. Record ID 71.

ee. Record ID 368.

ff. Record IDs 371, 372, 374, 375, 376, 377, 379, 380, and 1087.

Shippingport LWBR was an electric power reactor that converted of fertile Th232 to fissile U233. About 27% of the MTHM in this group is Shippingport LWBR reflector IV SNF.[gg] Shippingport LWBR reflector IV assemblies are rods in a rectangular array about 17.1 in. by 13.8 in. and 11.8 ft long. The Shippingport LWBR reflector IV SNF has an enrichment of about 98% and a burnup of about 2,200 MWd/MTU. The cladding condition of the Shippingport LWBR reflector IV SNF is generally good.

- **Group 26: Th/U Oxide, SST Clad**—This group contains thorium/uranium oxide fuel compounds with stainless steel cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 7.6 MTHM.

  The vast majority of the SNF in this group (66% of the MTHM and 90% of the canisters) is from the Elk River Reactor (EER). The ERR assemblies[hh] are rods in square arrays that are 1.4 inches wide and 5.3 feet long. There are some individual Elk River Reactor rods in addition to the assemblies. The Elk River Reactor SNF in this group has an enrichment of 96%. The Elk River Reactor SNF has a low burnup, about 5,400 MWd/MTU. The cladding condition of the Elk River Reactor SNF is generally fair.

  Group 27: U-Zirc Hydride, SST/Incoloy Clad, Highly Enriched Uranium—This group contains uranium zirconium hydride fuel compounds, U-ZrH_X-Er, with stainless steel or incoloy cladding. The cladding is in good to fair condition. This group of fuel comprises approximately 0.16 MTHM. Most of the SNF in this group was generated from numerous domestic and foreign Training Research Isotope General Atomics (TRIGA) research reactors, with no dominant single generator. The TRIGA SNF in this group is generally of the fuel life improvement program (FLIP) design. TRIGA FLIP rods are typically 1.5 in. in diameter and 2.4 ft long. The enrichment of the TRIGA FLIP SNF in this group has an enrichment ranges from about 60 to 70%, and the burnup ranges from about 9,400 to over 300,000 MWd/MTU. The cladding condition of the TRIGA FLIP SNF is generally good.

  Group 28: U-Zirc Hydride, SST/Incoloy Clad, Medium-Enriched Uranium—This group contains uranium zirconium hydride fuel compounds, U-ZrH_X and U-ZrH_X-Er, with stainless steel or Incoloy cladding. The cladding is in good to poor condition. This group of fuel comprises approximately 1.4 MTHM. The SNF in this group was generated from numerous domestic and foreign TRIGA research reactors with no dominant single generator. TRIGA rods in this group are typically 1.5 in. in diameter and 2.4 to 3.8 ft long. The TRIGA SNF in this group has enrichments ranging from about 12 to 20% with burnups ranging from very slight irradiation to nearly 95,000 MWd/MTU. The cladding condition of the SNF in this group is generally good.

- **Group 29: U-Zirc Hydride, Alum Clad, Medium-Enriched Uranium**—This group contains uranium zirconium hydride fuel compounds with aluminum cladding. The cladding is in good condition. This group of fuel comprises approximately 0.35 MTHM. The SNF in this group was generated from numerous domestic and foreign TRIGA research reactors, with no dominant single generator. The TRIGA rods in this group are typically 1.5 in. in diameter and 2.4 ft long. The TRIGA SNF in this group has enrichments ranging from about 17 to 20%. The SNF in this group has highly variable burnups, ranging from very slightly irradiated to about 37,000 MWd/MTU. The cladding condition of the SNF in this group is generally good.

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gg. Record ID 371.

hh. Record IDs 68 and 1057.

- **Group 30: U-Zirc Hydride, Declad**—This group contains uranium zirconium hydride fuel compounds that have been declad. This group of fuel comprises approximately 0.03 MTHM.

  All the SNF in this group (100% MTHM) was generated from the System for Nuclear Auxiliary Power (SNAP) Program Reactor. The SNAP elements[ii] are 1.2 inches in diameter rods 1.2 feet long. The SNAP SNF has an enrichment of slightly less than 90%. The cladding has been removed, so the cladding condition is not applicable.

- **Group 31: Metallic Sodium Bonded**—This group contains a wide variety of SNF that has the common attribute of containing metallic sodium bonding between the fuel matrix and the cladding. This group of fuel comprises approximately 59.9 MTHM.

  Current plans are to treat a portion of this SNF and dispose of it as high-level waste. The SNF in this group was generated primarily from various breeder reactors. Over half of the MTHM from the Fermi reactor, nearly half of the MTHM from the Experimental Breeder Reactor II, and a small amount was generated by the Fast Flux Test Facility reactor. A limited amount of SNF was generated as a result of irradiation of sodium-containing experiments in thermal reactors. The SNF consists of a variety of compounds (uranium and plutonium oxides, carbides, metals, and alloys). Most of the SNF in this group has stainless steel cladding. The SNF includes rods, rod arrays, and experiment capsules that range from 0.2 to 9.1 inches in diameter/width and 1.8 to 12 feet long. The SNF in this group has enrichments that range from depleted uranium (0.2%) to 93%. The SNF in this group has variable burnups ranging from low to high (2,000 to 100,000 MWd/MTU). The condition of the cladding is variable and is considered good, fair, or poor.

- **Group 32: Naval**—Naval SNF.

- **Group 33: Canyon Stabilization**—This SNF is being treated and will be disposed of as high-level waste.

- **Group 34: Miscellaneous**—This group contains SNF that does not fit into other groups. The SNF in this group was generated from numerous reactors of different types. This group of fuel comprises of approximately 0.44 MTHM. The dominant source (55% of the MTHM) is the KEMA SNF[jj] from the Aqueous Homogeneous Suspension Reactor, an experimental power reactor. The KEMA SNF consists of canisters of thorium-oxide and uranium-oxide scrap. The KEMA SNF has an enrichment of about 90%. The KEMA SNF does not have cladding.

5. REFERENCES

1. Query Name, *Final L.A. Query, 06/14/04*, File 1360.2, E-mail from A. Bringhurst, June 14, 2004.

2. Query Name, *Greg's Request, 05/10/03*, File 1360.2, E-Mail from A. Bringhurst, May 10, 2003.

3. EDF-NSNF-032, *DOE SNF Grouping Bases*, Revision 0, November 18, 2003.

4. EDF-NSNF-035, Revision 1, *Radionuclide Inventory Calculation Checks, Version 5.0.1*, December 22, 2003.

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ii. Record ID 206.

jj. Record ID 861.